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Distribution Network Based on Heuristic Search to Achieve Fault Recovery System

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Abstract

Structural features for the distribution network and distribution network fault recovery needs, connectivity analysis of distribution network into the global connectivity analysis and line analysis of two local dynamic statement. Distribution network run by the characteristics of radiation, the problem tree into power stratification. Powered by hierarchical tree to reduce the search space, to improve the speed of recovery and effective power supply to meet the real-time recovery. Using VC + +6. 0-mode integrated programming and technology plans, the development of distribution network reconfiguration system.

*Keywords:*Recovery; Topology analysis; Powered tree; Map module integration technology

1. Introduction

The main goal is to restore power in the distribution network fails, as soon as possible by network reconfiguration in the system security does not produce the more limited conditions, as much as possible and quickly restore failed areas of non-load loss of electricity supply. Recovery is a complex multi-objective optimization problem, many papers have been studied on the recovery algorithm. Typical algorithms are: the use of heuristic search methods to find possible recovery programs, and by the numerical calculation to determine the recovery of viable or optimal solution [1]. [2], service restoration using genetic algorithms; [3], parallel genetic algorithm for the use of space to improve the computing speed; the literature [4] introduced the artificial neural network; principle of fuzzy mathematics and fuzzy planning or evaluation, to determine the optimal [5-7]; [8] to Petri nets used for recovery. However, the

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existing literature are often uses an algorithm to process it, so often can not overcome the shortcomings of the algorithm itself.

In this paper, the structural characteristics of distribution networks and distribution network fault recovery needs, connectivity analysis of distribution network into the Global Topology Analysis and Topology Analysis of local dynamics of two. End line analysis to reduce the time taken to improve the end line of speed. Open loop radial distribution system according to the characteristics of power from one point of view, its power supply topology of each node is a tree structure to form the power tree. Powered by hierarchical tree in the hierarchical process of the loss of electricity load and loss of power feeder zone adjacent to off-line feeder margin calculation, the final use of the power supply has been hierarchical tree, with the heuristic search method to find possible restore the power supply lines.

1.1. Model of distribution network fault recovery

Network for the recovery of objective function:

- One of the goals is to restore power to as many users to recover lost electricity supply, namely

$$Max \sum_{i \in N_{out}} I_i \tag{1}$$

- Restoration of the goals is to make the operation of the switch two times as little as possible, that is,

$$MinN_{os} \tag{2}$$

Type (1) (2): N_{out} loss of electricity for all non-fault zone, I_i for the branch i of the load current; N_{os} is the number of switching operations. This paper argues that the goal to restore power are hierarchical, so the formula (1) is the absolute priority that most recovery programs should first restore the load; followed by the type (2), the switching operation can be reduced by reducing recovery time.

Constraints:

Flow equations system constraints are:

$$(P_i + jO_i) - \dot{U}_i \sum_{j=1}^{n} Y_{ij}^{*} \mathrm{U}_j^{*} = 0, \forall i \in N, \forall j \in N \tag{3}$$

Node voltage and branch current constraint is binding:

$$U_{i\min} \le U_i \le U_{i\max} \tag{4}$$

$$| I_i^p | \le | I_{i,Max} | \tag{5}$$

Network topology constraints are:

$$g \in G_R \tag{6}$$

Where, $P_i + jO_i$ is i, into the power of the node; N node set for the system; $\dot{U}_i$ is i for the node voltage phasor; Yij is the admittance matrix elements; I_i^p is i, p for the slip phase current; $I_{i,Max}$ i is the phase slip the maximum current; $U_{i\min}$, U_i , $U_{i\max}$ respectively, the minimum load point i allowed voltage, actual voltage and maximum voltage; g for the loss of electricity after the region to restore power grid structure; G_R for all possible radiation type.

2. Distribution Network Topology Analysis

2.1 Global distribution network topology analysis

Global Distribution Network Topology Analysis of the distribution network are mainly based on the connection between the various components and determine the status of each switch operation of the grid in real time, global connectivity analysis is divided into two steps: analysis of the relationship of Bus

connection; substation feeder attached The Topology Analysis. Through analysis of the relationship of Bus connection, you can determine the substation feeder by the number of connected points and the power supply point capacity. Feeder substation is connected through the junction line analysis, to determine the operation of the feeder. The end of each feeder line analysis method using breadth-first search. Through this two-step analysis, as shown in Figure 1 can be formed distribution network structure.

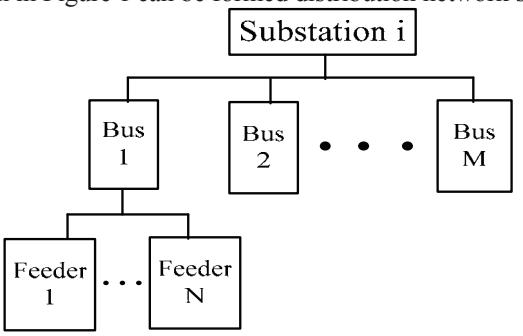

Fig.1 Distribution network structure

Feeder with double-layer topology, said tree topology, as shown in Figure 2, Figure 3. Distribution network, said upper outlet circuit breakers, disconnect switches, contact switches between the logical connection relationship, as shown in Figure 3 (a) below; lower that load nodes and load nodes and the switch near the connection between nodes, Figure 3 (b) below.

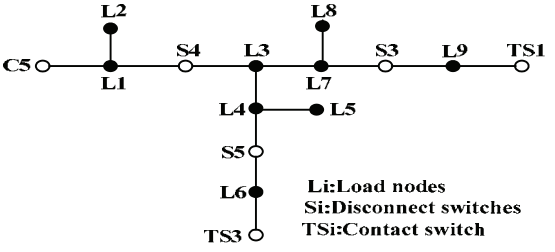

Fig. 2 Distribution Network of the original tree structure

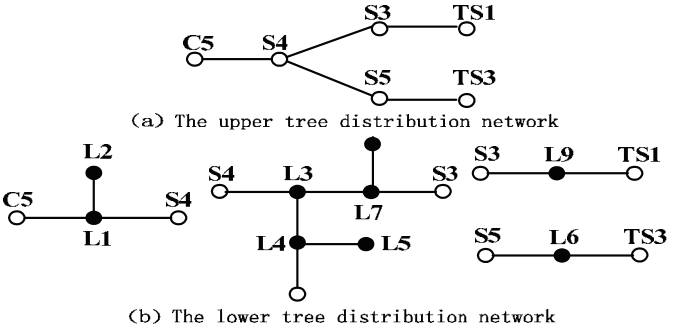

Fig. 3 Two-tier distribution network model of tree structure

2.2 Local distribution network dynamic topology analysis

In recovery, the recovery program will find a small part caused by changes in switch state, leading to the local distribution network topology changes. From the switch may be the result of modification of view, the switch can be divided into two distribution network, a circuit breaker inside the transformer substation, including the transformer low voltage side of the switch and the mother of the switch; the other is the

feeder switches, including substation outlet switch, disconnect switches on the feeder and contact switches. Substation circuit breaker opening and closing of the internal changes in the state of the power distribution network will point and change the capacity of the power points in the tie line analysis, only the connectivity they need to split or merge the bus to the substation. The feeder opening and closing of the switch changes the state of the connection status of the distribution network will change. Local dynamic analysis process shown in Figure 4.

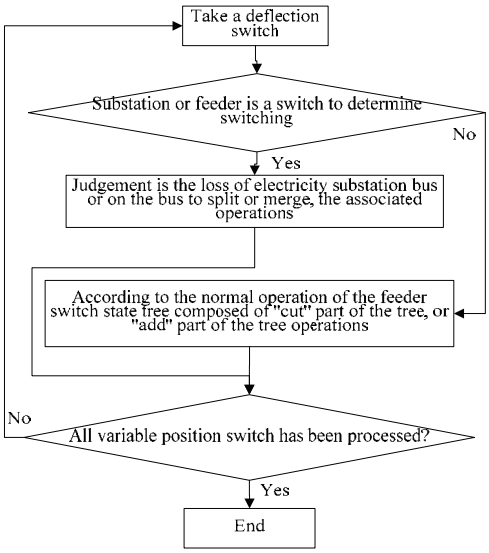

Fig. 4 Dynamic analysis of local flow chart

3. Algorithm

3.1 Generate a hierarchical tree

After the transformation of the general distribution network formed by the closed-loop design, the open-loop operation structure. From a power point of view, its power supply from the topology of each node can be thought of as a supply point to the root of the tree structure [9]. Therefore, the normal operation of distribution network, the radiation can be decomposed into multiple tree networks. A hierarchical supply tree shown in Figure 5.

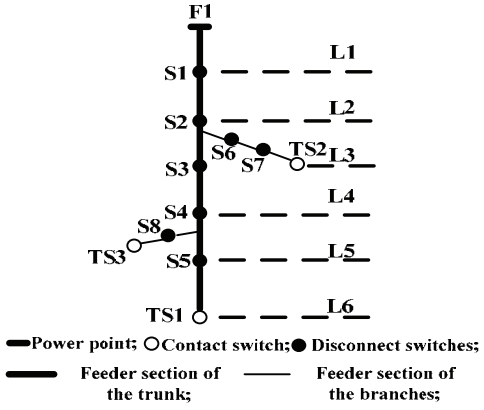

Fig.5 Distribution Network hierarchical tree diagram of power supply

Depth-first search method using stratified tree on the search for the root node of each switch according to the distance from the layer number generating sort, and gives each to the load, and the layer of the branches connected to the load is also taken into account, where the layers of the contact switch layers where its branches. Supply the tree shown in Figure 5, is divided into six layers, namely, L1 to L6, and calculate the load carried by each layer $Load_i$. L1 load carried by the load between the F1 and S1, L2 to S1 and S2 the load carried by the load between. So, you can get the load power tree layers.

3.2 Restoration method

The basic process of restoration method shown in Figure 6. Map: I_Σ is the total loss of electrical load; I_{M1} and I_{M2} for the two-level contact switches the spare capacity.

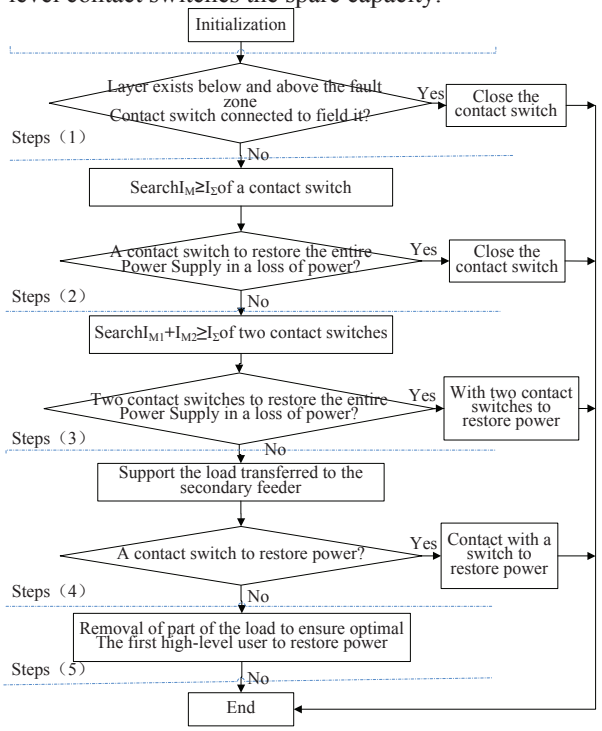

Fig.6 Distribution network restoration algorithm flow chart

If the fault point in the tree where the branches are directly connected only with the contact switch to restore power to areas lost power. In this case, only one restoration path option, no further path search. If you can not recover, then go to step (4) and the load transfer.

3.3 Evaluation of multiple candidate

Section 3.2 of the search strategies used may have multiple search strategies Therefore, some assessment methods need to decide which program best. Commonly used assessment method is fuzzy evaluation, fuzzy rules about assessment, by evaluating the select the best program. Fuzzy assessment of the literature on the lot, this will not repeat them.

4. Computation and Analysis of Programming

Based on the language for VC + + for development, the use of modular design, mainly by the physical library, the user graphical interface module, data processing system maintenance module, topology analysis module, network analysis and calculation module, reports, and print module and other accessories. graphical user interface consists of 4 framework, namely the menu toolbar, a list of area classification primitives, primitive property maintenance areas, primitive drawing area.

Automatic topology is a major feature of the program is the key to integrated graph model, the previous network analysis software typically need to manually enter the network topology and system parameters. Automatic Topology depth of breadth of search method used by some elements in the network connection port map coordinates to determine which components of the components and to form a slip aggregate information.

Figure 7 as part of a complex distribution network feeder wiring diagram, in order to ensure a clear picture, the figure omits the bus. The distribution network in the feeder section 33, 7 contact switches, disconnect switches 17, 6 feeders, 6 outlet breaker.

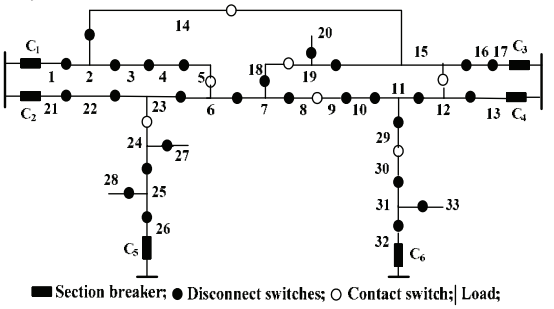

Fig.7 An example the distribution restoration

Branch is to figure 23 an example of its failure to supply a brief description of the recovery process. When the branch 23, failure, loss of electrical trouble-free region (6,7,8,18). Before the fault, has the power supply C_2 to the tree roots were divided into 6 layers, namely (21), (22), (23), (6), (7,18), (8). Let each load of $Load_i$. Slip fault tree trunk 23 in the power supply layer 3, the following contact layer 3 switch 5-6,18-19,8-9 may participate in the power restored. After calculation we can see, $I_{M(18-19)}$ the most, but the $I_{M(18-19)} < (Load_4 + Load_5 + Load_6)$, so only a contact closure switch can not restore power to the area lost power, you need two contact switches share the load area lost power, disconnect switches to open a distribution network to ensure that the radiation running. According to the steps in Section 3.2 (3), first consider the closed contact switch 5-6 and 18-19. $I_{M(5-6)}$'s supply area can be from 4 to 5 layers layer, $I_{M(18-19)}$ layer of the supply area from 6 to 5 layers, so as to open the disconnect switches and Layer 5 switches connected to two segments (6-7,7-8). Contact switch 5-6 and 18-19, respectively, where the layers 4,5 layer, an optional layer of disconnect switches between the 4,5 (6-7). Take (6-7,7-8) and (6-7) the intersection, you can open the disconnect switches 6-7 to form a recovery program ①. Where the feeder to the contact switch 5-6,18-19 check for three-phase flow, there is no safe limit, so the recovery is feasible. Similarly, closed 5-6 and 8-9, 7-8 to open the formation of the program ②; closed 18-19 and 8-9, 7-8 to form open plan ③. Three program areas can be restored to the loss of electricity supply options through the final fuzzy evaluation ①. The proposed algorithm used to recover, get shown in Table 1 recovery strategy.

Tab.1 The restoration plan

Fault slip	Recovery program	The final plan	Shear load / A	The number of switching operations
6	①close 18—19	①	0	1
21	①close 23—24，8—9，open 6—7 ②close 23—24，18—19，打开 6—7	②	0	3
23	①close 5—6，18—19，open 6—7②close 5—6，8—9，open 7—8 ③close 8—9，close 18—19，open 7—8	①	0	3
26	①close 18—19，open 7—18，close 23—24	①	0	3

5. Conclusions

In this paper, the structural characteristics of distribution networks and distribution network fault recovery needs, connectivity analysis of distribution network into the Global Topology Analysis and Topology Analysis of local dynamics of two. The whole network connectivity analysis can be used in initialization, and the local dynamic connectivity analysis can be used in the distribution network when the switch changes position, the distribution network to achieve fast dynamic connectivity analysis, greatly reducing the space occupied by end line analysis time and improve end line of speed.

Take full advantage of the operational characteristics of radiation distribution network, the problem is transformed to the power supply point for the root of tree problem, and will supply the tree layer, greatly reducing the search space and complexity of the problem.

The use of hierarchical supply tree search method can significantly reduce sections / contact number of switching combinations, and avoid some of the feeder full load, and some of the feeder is lightly loaded situation, ensure the load balance of each feeder.

References

[1] Miu N K,Chiang H D,Yuan B,et al.Fast service restoration for large-scale distribution systems with priority customers and constraints[J].IEEE Trans on PWRS,1998,13(3):789-795.

[2] Kyeong Jun Mun,Park J H,Hyung-Su Kim,et al.Development of real-time-service restoration system for distribution automation system[J].IEEE International Symposium on In-dustrial Electronics.2001,(3):1514-1519.

[3] Fukuyama Y,Chiang H D,Miu K N.Parallel genetic al-gorithm for service restoration in electric power distribution systems[J].International Journal of Electrical Power＆Energy Systems,1996,18(2):111-119.

[4] Lu C N,Tsay M T,Hwang Y J,et a1.An artificial neural network based trouble call analysis[J].IEEE Trans on Power Delivery,1994,9(3):1663-1668.

[5] Kuo H C,Hsu Y Y.Distribution system load estimation and service restoration using fuzzy set approach[J].IEEE Trans actions on Power Delivery,1993,8(4).

[6] Lee S J,Lim S I,Ahn B S.Service restoration of primary dis-tribution system based on fuzzy evaluation of multi-criteria[J].IEEE Trans actions on Power Systems,1998,13(3):1156-1163.

[7] Hsu Y Y,Kuo H C.A heuristic based fuzzy reasoning approach for distribution system service restoration[J].IEEE Trans on PWRD,1994,9(2):948-953.

[8] Wu Jaw-Shyang,Liu Chen-Ching,Liou Kan-Lee,et a1.A petri net algorithm for scheduling of generic restoration actions[J].IEEE Trans on Power Systems,1997,12(1):69-76.

[9] Wu Wenchuan，Zhang Boming．A candidate restoring tree cutting based algorithm for real-time distribution system restoration[J]．Automation of Electric Power Systems，2003，27(12):50-54